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ABSTRACT

The results of a National Science Foundation survey of 181 engineering colleges are summarized in this report which focuses on the extent of and reasons for faculty vacancies and effects of staffing problems. Major findings indicate that: (1) most deans of engineering colleges believe that difficulties in filling faculty slots have impaired the quality of research and instructional programs at their institutions; (2) approximately 10% of the 16,200 full-time engineering faculty positions available in 1980/81 were not filled; (3) the percentage of positions that were unfilled varied by field with the highest vacancies in industrial engineering (13%) and computer science/computer engineering (16%) and lowest (4%) in aeronautical/astronautical engineering; (4) nearly 9 out of 10 institutions have difficulty in filling vacant positions; (5) teaching loads have been increased and courses eliminated to adjust for vacancies; (6) engineers from other countries have helped to fill the faculty shortage; and (7) decreased numbers of new doctoral engineers and industrial competition may account for the current shortage of engineering faculty. (JN)

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SCIENCE RESOURCES STUDIES HIGHLIGHTS

NATIONAL SCIENCE FOUNDATION WASHINGTON, D.C. 20550 NOVEMBER 2, 1981 NSF 81-322

Engineering Colleges Report 10% of Faculty Positions Vacant in Fall 1980

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These Highlights present the results of a survey of the 181 engineering colleges that belong to the Higher Education Panel, a stratified sample of 760 of the more than 3,000 postsecondary institutions in the United States. The survey, supported by the National Science Foundation (NSF), was conducted during the fall of 1980 by the American Council on Education. Responses were obtained from 88 percent of those surveyed, and were weighted to represent the 244 U.S. engineering colleges that had at least one accredited degree program in 1979.

Highlights

- Most deans of engineering colleges believe that difficulties in filling faculty slots have impaired the quality of research and instruction programs at their institutions. Of the 16,200 full-time engineering faculty positions, about one-tenth were vacant at the beginning of the 1980/81 academic year. Two-fifths of these had been vacant at least one year. (Even though a small fraction of positions were filled by full-time temporary faculty, they were still considered to be vacant because attempts had been made to fill them with permanent staff.)
- The percentage of positions that were unfilled varied substantially by field. The two fields with the highest vacancy levels were industrial engineering (13 percent of slots unfilled) and computer science/computer engineering(16 percent). The lowest vacancy level was in aeronautical/astronautical engineering (4 percent).
- Nearly 9 in 10 engineering colleges reported that within the preceeding five years there had been a decrease in their ability to staff full-time positions. Reduced numbers of new engineering doctorates and increased competition with industry have accounted for much of this change.
- Of the colleges that experienced decreased ability to recruit or retain faculty, 80 percent adjusted by increasing teaching loads, and about 50 percent adjusted by eliminating courses in certain subjects.
- Engineers from other countries have helped to fill the shortage of faculty. Almost one in four junior faculty in engineering had received a bachelor's degree outside the United States.

Introduction

Widespread concern has developed in recent years about whether engineering colleges will have sufficient numbers of faculty to instruct an alltime high number of undergraduates while maintaining their R&D efforts.[1] Notwithstanding the breadth of this concern, there have been no published figures on the national extent of vacancies in each of the major engineering fields.[2] This *Highlights* fills that gap by reporting the results of an NSF-supported survey, "Recruitment and Retention of Full-Time Engineering Faculty, Fall 1980." The American Council on Education conducted this survey of engineering colleges that belong to its Higher Education Panel. Results were weighted to represent the 244 colleges of engineering that had at least one accredited program in 1979.

To understand better the causes and implications of the vacancy problem, the survey's scope extended beyond the number of empty faculty slots in engineering colleges. Engineering deans expressed their opinions on (1) whether their colleges had less ability now than five years earlier to recruit or retain faculty, (2) the effects of vacancies upon research and instructional programs, (3) whether competition for faculty had increased with industry—the chief nonacademic employer of engineering doctorates, and, if so, (4) the reasons for the increased competition. A question concerning the number of faculty who have moved to industry permits measurement of the magnitude of such sectoral mobility. Finally, the survey dealt with the related issue of the extent to which engineering colleges rely upon foreign faculty. In order to help

[1] For a general discussion of the problem of engineering faculty shortages, see the 1980 National Science Foundation-Department of Education report, *Science and Engineering Education for the 1980's and Beyond* (Washington, D.C.: Supt. of Documents, U.S. Government Printing Office).

[2] For complete details on the American Council on Education survey, see *Recruitment and Retention of Full-Time Engineering Faculty, Fall 1980*, Higher Education Panel Report No. 52 (Washington, D.C.).

Prepared in the Supply and Education Analysis Group, Division of Science Resources Studies

SE 035 936

explain why engineering doctorates are now in short supply, this *Highlights* incorporates information from sources other than the survey.

Extent of Faculty Vacancies

A significant number of engineering faculty positions were vacant at the beginning of the 1980/81 academic year. Deans reported that about 1,600 of 16,200 full-time slots were unfilled and that two-fifths of these had been vacant at least one year. These included only positions for which faculty had actually been recruited. Such slots, even when filled, were counted as being vacant if they were held by visiting or other temporary faculty. (A telephone followup of several survey respondents found that, in fact, a small fraction of positions reported as being vacant were filled by full-time, nonpermanent faculty.) Publicly supported colleges, which employed almost three-fourths of faculty, had a somewhat higher vacancy percentage than did private institutions (11 percent versus 8 percent). The higher figure for public institutions reflects the greater difficulty that public engineering schools affiliated with 4-year colleges have in staffing. These engineering schools reported about one in seven positions vacant, almost three times the rate for their counterparts in private 4-year colleges.

Vacancy data were tabulated separately for the 50 institutions that expended the most funds for research and development in engineering in fiscal year 1979. The "top 50" engineering colleges, which employed about one-third of engineering faculty, had a slightly lower proportion of positions unfilled than did the remaining colleges, 8 percent versus 11 percent.

All of the engineering fields surveyed, with the exception of aeronautical/astronautical, had vacancy proportions near or above the aggregate rate of one-tenth (chart 1).[3] Shortages appear to have been most severe in computer science/computer engineering, which had one-sixth of its positions unfilled.[4] Industrial engineering ranked second in the percentage of positions vacant. The highest percentage of full-time slots without incumbents (21 percent) was recorded for industrial engineers in public 4-year institutions.

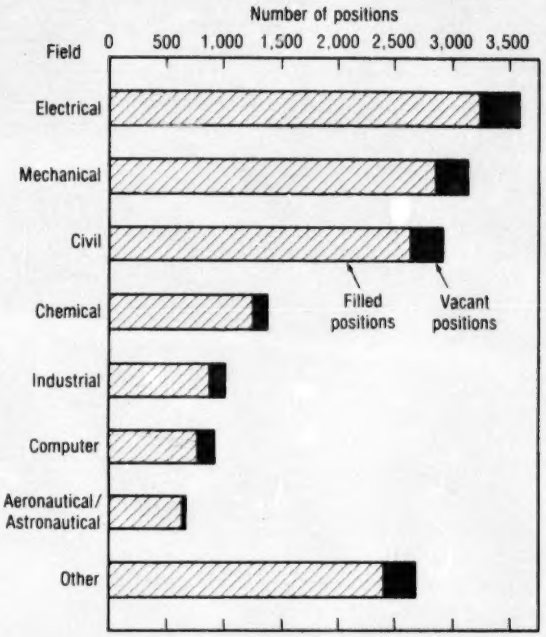
Nearly 9 in 10 engineering colleges reported that during the preceeding five years there had been a decrease in their ability to recruit or retain full-time faculty (table 1). Privately supported institutions were more likely to report a slight or moderate decrease in their staffing ability, and public institutions were more likely to report a substantial decline.

Reasons for Faculty Vacancies

Decreased numbers of new doctoral engineers may be the chief factor creating the current shortage of engineering faculty. Most engineering deans report that competition from industry for engineering faculty has grown in recent years, thus adding to the difficulty of filling faculty slots.

Chart 2 presents total engineering doctoral degrees for 1965-80 and the number awarded to nonimmigrant aliens. The latter must change their visa status to become permanently employed in this country, and, hence, would not normally be considered as additions to the U.S. labor force. In spite of this, many of those new engineering doctorates on temporary visas have planned to work in the United States after graduation.[5]

Chart 1. Full-time engineering faculty positions by field and status: fall 1980



SOURCE: National Science Foundation

Table 1. Reported changes during 1975-80 in the ability to recruit or retain permanent faculty

Change	All engineering colleges	Public engineering colleges	Private engineering colleges
	(Percents)		
Total	100	100	100
A substantial increase	4	5	0
A slight or moderate increase	3	3	3
No change	5	1	12
A slight or moderate decrease	37	27	55
A substantial decrease	51	64	29

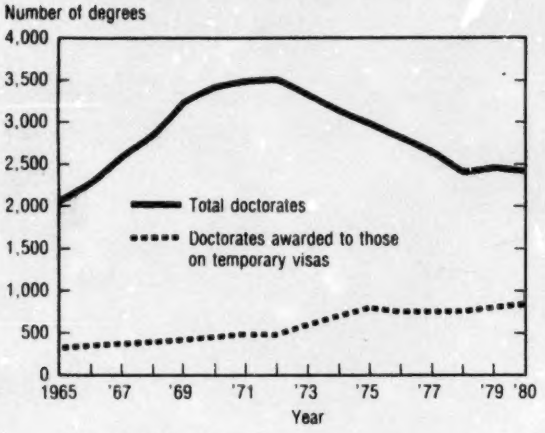
SOURCE: National Science Foundation

[3] Faculty were classified by field rather than by department. Therefore, the survey collected data, for example, on the number of faculty who were electrical engineers, rather than on the number in electrical engineering departments.

[4] The survey was restricted to faculty working in the college of engineering. Data on computer science faculty in other divisions of the affiliated institutions are not included in these estimates.

[5] In 1980, about one-half of those doctoral engineering graduates on temporary visas who had definite plans planned to work in the United States. Unpublished tabulations from the "Survey of Doctorate Recipients."

Chart 2. Doctoral awards in engineering



SOURCE: National Research Council

Normally, the numerous employment opportunities for new engineering Ph.D.'s during the late seventies would have prompted many with baccalaureate degrees to earn doctorates. This result has not yet become evident, although graduate engineering enrollments are rising. (According to the Engineering Manpower Commission, full-time graduate enrollment reached 44,000 in the fall of 1980, compared with 37,000 in 1975 and 38,000 in 1970.)[6] In spite of such growth, the National Center for Education Statistics projects a further decrease in the number of doctoral degrees awarded in engineering.[7] If, in fact, the number of Ph.D.'s in the field does not expand, the chief reason may be the strong incentive that recipients of bachelor's and master's degree have to enter the labor force immediately rather than forego two or more years of high salaries while earning a doctorate. In 1981 baccalaureate engineers were offered as much as $26,500 per year (petroleum and chemical engineering). Inexperienced chemical engineers with master's degrees also received average job offers of about $26,500. For comparison, an assistant professor in engineering received a 1980/81 9-month salary of about $22,000.[8]

Fewer new engineering Ph.D.'s are graduating at a time when industry's interest in them has grown. Nine out of ten deans reported that within the preceeding five years competition with industry for doctoral engineers had become more intense. No dean believed competition had slackened. Of those who indicated that industrial employment was claiming larger number of potential faculty, some three-fourths believed that financial benefits in the for-profit sector were the chief attraction.

The impact of industrial competition may be reflected more in the difficulty of recruiting faculty from among new Ph.D. recipients than in retaining those with experience. According to the deans, only about 3 percent of those who were full-time faculty in permanent positions during the 1979/80 academic year voluntarily moved to full-time work in industry. Only engineering faculty who worked in the field of computer science had a substantially higher mobility rate (chart 3). The 50 colleges with the largest engineering R&D expenditures lost only about 2 percent of their 1979/80 faculty to industry. This mobility rate is close to that found for faculty of doctorate-granting departments of chemical, civil, electrical, and mechanical engineering in another NSF survey.[9] For the surveyed departments, the latter survey also found that the movement of experienced engineers from full-time industrial employment to full-time faculty positions compensated for most of the personnel losses to industry.

The problems caused by smaller supplies of potential new faculty and keener competition from industry are exacerbated by the burden of instructing larger numbers of undergraduates. Between 1972 and 1980 engineering freshman enrollment more than doubled. Moreover, during this same period, expenditures for research in engineering colleges grew by about 25 percent in real terms, further adding to the demands upon faculty.[10]

Effects of Staffing Problems

Those deans who reported that their colleges were experiencing greater difficulty in recruiting or retaining faculty described how the staffing problems affected their institutions. Choosing from a list of options of possible negative effects, only one-third indicated that the faculty vacancies had forced their remaining staff to reduce their research activities (table 2). Four-fifths, however, believed that teaching loads had increased, and one-half that their colleges were unable to offer courses in certain subjects because of the vacancy problem. To reduce the burden on full-time faculty, about two-thirds of the colleges experiencing greater staffing difficulty increased their use of graduate teaching assistants or part-time faculty. This recourse was more widely taken by publicly than by privately supported engineering colleges.

The deans also reported how decreased ability to recruit or retain full-time faculty had affected the quality of their colleges' research and instruction programs (table 3). About 70 percent, excluding those who did not report increased staffing problems, believed both research and instruction had suffered slight to moderate declines in quality. In both areas, private engineering college deans tended to describe the decreases as slight, whereas their public institution counterparts were about evenly divided as to whether the declines were slight

[6] Engineering Manpower Commission. *Engineering and Technology Enrollments, Fall 1980* (New York, N.Y., April 1981), p. 6.

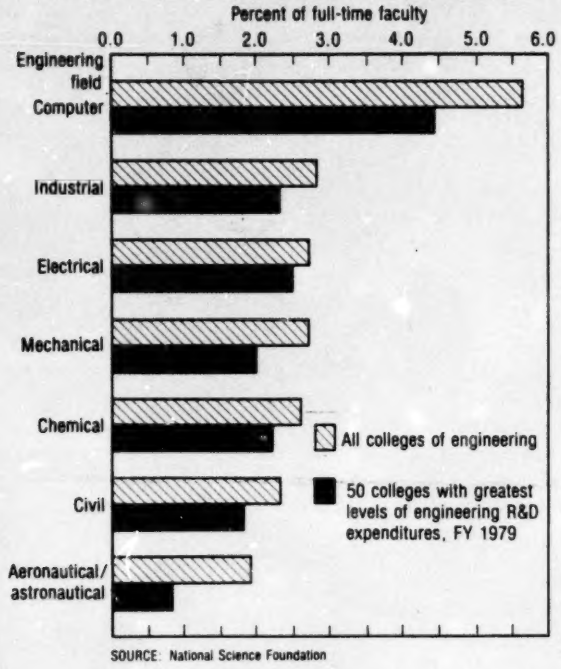
[7] Department of Education, National Center for Education Statistics. *Projections of Education Statistics to 1988-89* (NCES 80-402) (Washington, D.C.: Supt. of Documents, U.S. Government Printing Office).

[8] *College Placement Council Salary Survey, A Study of 1980-1981 Beginning Offers*, (Bethlehem, Pa.: College Placement Council), July 1981 and American Association of Engineering Societies, *Data Related to the Crisis in Engineering Education* (New York, N.Y.), March 1981.

[9] National Science Foundation. *Young and Senior Science and Engineering Faculty, 1981* (NSF 81-319) (Washington, D.C.), 1981.

[10] National Science Foundation. *Academic Science: R&D Funds, Fiscal Year 1979* (Detailed Statistical Tables) (NSF 81-301) (Washington, D.C.), 1981.

Chart 3. Full-time engineering faculty moving to employment in industry after 1979/80 academic year



SOURCE: National Science Foundation

or moderate. Only 10 percent of those answering this survey question believed that instruction had declined greatly in quality, and only 6 percent responded that research quality had fallen sharply.

One effect of the shortage of doctoral engineers has been to provide academic employment to engineers from abroad. Without this group, faculty vacancies in engineering colleges would be far more extensive than reported here. Among junior engineering faculty (those with the rank of instructor or assistant professor), almost one in four had received the bachelor's degree outside the United States. Those with foreign baccalaureates constituted one-third of the junior faculty at public 4-year engineering colleges, the highest level of concentration of faculty with foreign undergraduate training.

Table 2. Adjustments in faculty teaching and research required because of recruitment/-retention difficulties

Effects	All engineering colleges[1]	Public engineering colleges	Private engineering colleges
	(Percents reporting)		
A reduction in faculty research	35	37	30
An increase in teaching loads	80	81	79
Greater reliance on graduate teaching assistants or part-time faculty	66	77	42
Inability to offer courses in certain subjects	54	55	51
Other	21	18	24
No significant effect as yet	8	6	10

[1]For only those 215 colleges reporting decreased ability to recruit or retain faculty.

SOURCE: National Science Foundation

Table 3. Effect of recruitment/retention difficulties on quality of research and instruction

Extent of decrease in quality	All engineering colleges	Public engineering colleges	Private engineering colleges
	(Percents reporting)		
Research, total	100	100	100
No decrease	25	24	26
Slight decrease	40	35	53
Moderate decrease	29	33	19
Great decrease	6	8	2
Instruction, total	100	100	100
No decrease	18	17	21
Slight decrease	41	33	56
Moderate decrease	31	36	21
Great decrease	10	13	3

SOURCE: National Science Foundation

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